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THE SORT TECHNIQUE
FOR ASSESSING TECHNICAL QUALIFICATIONS

by



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A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES
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The undersigned hereby certify that they have read and recommended to the Faculty of Graduate Studies, a thesis entitled, "The Sort Technique for Assessing Technical Qualifications," submitted by Milton William Petruk in partial fulfillment of the requirements for the degree of Master of Education.

ABSTRACT

This study was conducted to investigate the applicability of the sort technique as a means of assessing technical qualifications of electronics teachers in Alberta high schools.

Two groups of subjects were included in this study. One group, referred to as the control group, consisted of thirty-eight high school students who were studying electronics. The other group, referred to as the experimental group, consisted of thirty-two electronics teachers and student teachers.

Four sets of sort cards, each containing fifty concepts, were specially developed for this study. These cards contained concepts representative of concepts specified in the Electronics section of The Alberta Vocational Series Senior High School Curriculum Guides.

Every individual in the two groups of subjects sorted the cards into nine ordinally numbered piles on the basis of difficulty as perceived by the sorter. The purpose for this was to determine whether the subjects in the control group, who were in the process of studying to become qualified in electronics, sorted differently than

subjects in the experimental group, who were all technically qualified in the field of electronics. The results of the individual sorts were correlated with each other and then subjected to factor analysis. The factor loadings were then analyzed using cutting scores. The results showed that the subjects in the control group loaded more heavily on one factor while the subjects in the experimental group loaded more heavily on a different factor. This seemed to indicate that the sort was capable of separating subjects into groups on the basis of their technical qualifications.

The sort results of the experimental group were then examined in order to determine whether subjects within this group sorted differently from each other. All sort results for the experimental group were correlated with each other and then subjected to factor analysis. Five factors based on technical qualifications were examined. Of these, only one factor showed a statistically significant difference in relation to a single sort. Three other factors showed differences that approached significance. All remaining differences were not statistically significant. Therefore, on the basis of these sorts, it was not possible to establish whether differences existed between subjects within the experimental group. It was suggested that whenever larger

populations of this type become available, this study should be replicated.

The sort technique, such as the one used in this study, seems to have potential as a method of evaluating technical qualifications. This may prove of value to vocational administrators and teacher educators in their selection of prospective candidates for teacher education programs.

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CHAPTER I

INTRODUCTION AND FORMULATION OF THE PROBLEM

I. INTRODUCTION

In December of 1960, the Federal Government of Canada passed a new Technical and Vocational Training Assistance Act that provided for payment by the Federal Government of seventy-five per cent of costs incurred in the establishment of technical and vocational training facilities. A progress report published by the Federal Government in Technical and Vocational Education in Canada, dated March 31, 1966, indicated that this Act resulted in 350,000 new student places across Canada, 34,000 of which were in Alberta. These student places included facilities for various vocational subject areas, one of which was Electronics.

The Alberta Department of Education specified that teachers involved in the preparation of high school students for future employment in the electronics field must be technically qualified. Since the term, "technically qualified," has not been objectively set out, a more subjective approach to the assessment of technical or trade qualifications is currently used.

Trade qualification is to be approved by an admissions sub-committee composed of the Dean of the Faculty of Education, the Head of the Department of Industrial and Vocational Education, the University Admissions Secretary, the Chairman of the Provincial

Apprenticeship Board, and the Supervisor of Vocational Education of the Department of Education.
(The University of Alberta Calendar, 1967-68, p. 64.)

Stephenson (1953, p. 86) suggests that "Q-technique provides a systematic way to handle . . . (assessments) . . . of an apparent 'subjective' nature." An assessment of the Q-technique as an instrument for use by educators will be made by administering sorts constructed for this purpose to a control group composed of high school students and to an experimental group composed of teachers and student teachers.

II. STATEMENT OF THE PROBLEM

This study was conducted in order to evaluate the applicability of the sort technique for isolating specified factors related to technical qualifications of electronics teachers in vocational high schools in the Province of Alberta.

Specific Problems

The specific problems were to:

(1) determine what differences, if any, were observed by means of the sort technique, between the control group (high school students) and the experimental group (teachers and student teachers) used in this study;

(2) determine what differences, if any, were observed by means of the sort technique, between members or groups of members within the experimental group of

teachers and student teachers used in this study; and

(3) determine what the implications of these differences were, if any.

III. DELIMITATIONS

The control group used in this study included thirty-eight high school students who were, at the time of this study, registered as full-time students at Victoria Composite High School, Edmonton, Alberta, and who were enrolled in either Electronics 12/22 or Electronics 32. The students selected for participation in the control group were considered to be representative of electronics students in composite high schools throughout the province on the basis that Victoria Composite High School drew its student population from the entire city of Edmonton. These students constituted two classes, both taught by the same teacher and both readily accessible for participation in the study.

The experimental group used in this study included thirty-two subjects who, after having demonstrated a satisfactory standard of competence in the field of electronics, were granted advanced standing in the Department of Industrial and Vocational Education, Faculty of Education, University of Alberta. All these subjects were either registered as full-time student teachers in the Department of Industrial and Vocational Education, or

employed as certified electronics teachers in Alberta high schools, after having been enrolled as student teachers in the Department of Industrial and Vocational Education. Since the number of subjects who could qualify for participation in the experimental group (teachers and student teachers) was small, it was decided to administer the sort to the total population of the experimental group.

IV. ASSUMPTIONS

1. Since the control group used in this study consisted of high school students studying electronics, and since the experimental group consisted of high school electronics teachers and student teachers of electronics, it seemed logical to assume that the subjects in the experimental group were more highly qualified in the field of electronics than were the subjects in the control group.

2. It was assumed, also, that the following were significant factors that affected or influenced the technical qualifications of the members of the experimental group:

- (a) the institution at which technical training was received;
- (b) the kind of work experience possessed by the subjects; and
- (c) the length of time that had elapsed since formal technical training was completed.

3. Finally, it was assumed that, whenever subjects were confronted with concepts that were relatively unfamiliar to them, they would not be likely to sort these

concepts consistently with the concepts that they knew. Therefore, it was assumed that any inconsistency in sorting would be a measure of a lack of technical qualification. An example serves to illustrate this assumption. If a subject who had never worked with or studied transistors encountered a concept in the field of transistors, the subject would be unable to judge the difficulty of the concept relative to those concepts he knew. It was assumed that the subject would likely place this card in a position in the sort that would be inconsistent with the rest of the sort. Thus, by examining a subject's sort for such inconsistencies, it would be possible to assess his technical qualifications.

V. STATEMENT OF HYPOTHESES

The following hypotheses were tested in this study.

(1) The sort technique used in this study will differentiate between the experimental group and the control group on the basis of their technical qualifications.

(2) The sort technique used in this study will differentiate between subjects within the experimental group on the basis of their technical qualifications.

VI. DEFINITION OF TERMS

Satisfactory Standard of Competence

A "satisfactory standard of competence" in the field

of electronics was operationally defined as the standard that qualified a subject with a technical competence in the electronics field for admission with advanced standing to the Vocational Education Program in the Department of Industrial and Vocational Education, Faculty of Education, University of Alberta.

Technical Qualifications

The term, "technical qualifications," was operationally defined as those combinations of technical training and work experience in the field of electronics that determined a subject's level of proficiency in that field.

Sort Technique

The term, "sort technique," as used in this study, was operationally defined as a method of collecting data often referred to as Q-sort or Q-technique by literature in the field of psychology. Each subject in this study was given a number of cards, each card containing a selected concept from the field of electronics. Each subject was instructed to "sort" the concepts into nine categories according to a specified criterion. When the "sort" was completed, the identification numbers of the sorted cards were placed in each of the nine ordinally numbered categories on an answer sheet, to be used as data for this study.

VII. NEED FOR THE STUDY

The purpose of this study was to determine the applicability of the sort technique as an instrument for assessing the technical qualifications of vocational teachers of electronics. Educational literature indicates that there are diverse viewpoints among educational authorities as to what constitutes an adequate preparation for technical and vocational teachers.

Broudy (1962, p. 374) did not make any distinction between the area of specialization of vocational education teachers and their teacher preparation program. He stated:

We can clarify the educational requirements for the good teacher by noting that the high-gradedness, as far as it can be deliberately produced, is a product of (1) general education, (2) the science of teaching as contained in educational theory, and (3) apprenticeship in actual teaching.

Dewey, however, placed more stress on knowledge of subject matter. In his book, John Dewey As An Educator, Arthur G. Wirth (1966, p. 56) stated:

Dewey argued that a healthy profession requires teachers who have learned to apply the habits of critical thought to their work. To do this, they must have a full knowledge of their subject matter, and observe and reflect in terms of psychological and philosophical concepts.

Mursell (1934, p. 477) appeared to agree with this concept. He stated that "For flexible, creative teaching, the mastery of subject matter is an absolutely indispensable condition." He cited as an example that ". . . it is impossible to teach French by direct conversation, unless

one can talk the language freely."

French (1955, p. 161) in his treatment of the subject of teacher preparation, stated that a "... requisite for success in teaching is that the teacher should know thoroughly the subject matter used in his field of specialization." Power (1962, p. 237) wrote that "It is futile or worse for the teacher to try to communicate what he himself does not know."

Glendenning, writing in relation to the administration of the Technical and Vocational Assistance Act (1964, p. 9), seemed to agree with this latter position. He wrote:

The technical and vocational teacher, like any other teacher, must possess:

- (1) a sound general education beyond matriculation,
- (2) professional education including practice teaching, and
- (3) competence in a teaching area.

Further evidence of the acceptance of this position may be found in the Calendar of the Faculty of Education, University of Alberta (1967, p. 64), where the following list of entrance requirements for the teacher education program in vocational education was included:

- (1) Trade training as verified by a recognized certificate of qualification or equal; and
- (2) Experience in a trade or industry calling for the trade training held.

In administering the program of vocational teacher

education, the University of Alberta has established an admissions sub-committee (1967, p. 64) which subjectively assesses technical qualifications of subjects applying for entry into the program for vocational teacher education. Other institutions have attempted to use more objective means of assessing technical qualifications. Kazanas and Kieft (1967, p. 27) examined the problem of technical qualification and found that competency examinations, consisting of oral, written, and/or performance tests have been used by vocational educators for many years and for many purposes. They found, however, that most of those examinations had not been standardized or refined. They concluded that the many possible uses of competency examinations by vocational educators suggest that further research and development should be channeled in this direction.

Stephenson (1953) proposed greater use of a measuring technique which he referred to as Q-technique, which simply consists of analyzing the manner in which a subject has arranged a number of test cards along a specified dimension. Such a technique offers several advantages. First, it takes away the stress-producing situation that is associated with formal examinations. Second, it is possible to administer a Q-sort without a proctor. In this regard, Sheldon and Sorenson (1960, p. 150) concluded that "Since Q-sorting presents the subject with a more complex

task, it would presumably be hard to fake." This would make a Q-sort highly desirable whenever data is collected by mail. Finally, Mowrer (1953, p. 316) pointed out that, since the Q-technique required a considerable number of items, it could be used, with good reliability, where a small population was involved.

It was on this basis that the present study, involving an inquiry into the use of the sort technique for evaluation of technical qualifications of electronics teachers was conceived and conducted.

CHAPTER II

RELATED LITERATURE

The purpose of this study was to conduct an evaluation of the sort technique as an instrument for assessing technical qualifications of electronics teachers. Numerous studies had been conducted for the purpose of evaluating vocational teachers by means of oral, written, and/or performance examinations. However, no evidence in the related literature was found to indicate that the sort technique, which has earned a prominent place in the field of psychology, had ever been used as an instrument for assessing technical qualifications of electronics teachers.

The related literature in this chapter deals mainly with a review of the development of the sort technique as a measuring instrument and with a review of several studies involving the use of the sort technique as a measuring instrument.

I. THE DEVELOPMENT OF THE SORT TECHNIQUE AS A MEASURING INSTRUMENT

Mowrer (1953, p. 316) traced the growth of the sort technique through three phases of development. Phase 1 extended from 1912 to 1935. During this phase, Spearman performed an analysis of a score matrix by correlating the results of several tests given to the same group of people.

He followed this with a factor analysis of the correlations. Later, in 1926, Thomson and Bailes carried out a correlation of test results between people in an attempt to assess test reliability. Mowrer reports that Burt and Moore concluded that a factor analysis of correlations of test results would lead to an isolation of personality traits, while a factor analysis of correlations between people would yield an identification of personality types.

Mowrer's Phase 2 extended from the end of Phase 1 (1935) to 1942. Mowrer explained that, while correlations between persons had been used much earlier, it was in 1935 that Thomson and Stephenson made the first explicit references to the use of correlation between persons in connection with factor analysis. Mowrer reported a controversy between Thomson, who saw little value in such correlations, and Stephenson, who saw great potential in them. Thomson wrote that it was ridiculous to compare people on the basis of different factors and that it could be compared to adding apples and oranges. Stephenson pointed out that measurement for a common factor, whatever that factor was, could be likened to measuring apples and oranges on a common factor of weight. It was on this basis that he advocated the use of Q-technique as an essential instrument for general and type psychology for isolating types of persons and supplying indices of such types. He later referred to the ability of this technique ". . . to measure persons in terms of

standard persons" (1936(a), p. 294). Mowrer also referred to the writings of Burt (1940) who felt that this technique was suited to all those inquiries in which the performances of persons examined had to be compared with a subjective rather than with an objective standard, and Wolfe (1940) who indicated that Stephenson's obtained factors represented types of individuals. Wolfe explained that it was possible to give each individual a score which would indicate his degree of approximation to, or his correlation with, the most typical person.

Mowrer's Phase 3 extended from the end of Phase 2 (1942) to the time of writing (1953). During this phase, developments were characterized by Bordin's proposed use of the sort on the same group on two different occasions in order to detect the extent to which a change had occurred during the time interval between tests.

Cattell (1951, p. 203) synthesized the developments that occurred during Mowrer's three phases graphically by means of his Covariation Chart. He wrote:

. . . there are essentially three fundamentals
. . . among which the relations of correlations
can be established. . . . They are: people (or
organisms); tests (or behavioral performances of
any kind); and occasions (on which tests and people
interact).

If correlations are carried out within a universe of people, this is referred to as the Q-technique. If correlations are carried out within a universe of occasions, this is referred to as the P-technique. Finally, if correlations are carried

out within a universe of tests, this is referred to as the R-technique.

Lee J. Cronbach (1953, p. 376) explained that, aside from a few studies carried out by Stephenson himself, practically no use was made of this type of correlation until 1948. He wrote:

First, the Q-sort . . . provides a flexible method of obtaining a qualitative description of the individual in the form of rigorous manipulation. Second, the Q-sort permits comparison of many different personas which coexist as features of the same individual. Third, it . . . provides a basis for studying homogeneity of groups.

He further stated, with respect to the applicability of the sort technique, that "So far as present research indicates, almost any set of statements can be the basis for investigations of correlations between persons."

II. STUDIES INVOLVING THE USE OF THE SORT TECHNIQUE AS A MEASURING INSTRUMENT

Until 1948, Stephenson remained the major proponent of the sort technique. His writings (1935a, 1935b, 1936a, 1936b, 1936c, 1950a, 1950b, 1952) advocated and illustrated many varied applications of the sort technique and culminated in a book on the topic in 1953. In this book, Stephenson proposed the use of this technique as the key to investigation of the self-concept, psychoanalytic theory, projective techniques and the individual personality. He stated that his methods enabled one to study the individual

objectively and systematically in an interactional setting, without regard for norms or individual differences.

Gottschalk and Averbach (1966, p. 437), in their review of methods of research, referred to studies by Hartley in 1951, Butler and Haigh in 1954, Nunally in 1955 and Shlien in 1960, in which clients were asked to sort items throughout various stages of their therapy for the purpose of noting changes. All of these studies were of the test-retest type identified by Cattell as P-techniques. Gottschalk and Averbach also reported on a variation of these studies as carried out by Butler in 1960, wherein he applied factor analysis to sorts to establish factors representing different intherapy behavior and outcome.

Fiedler (1951, p. 101) described a series of studies wherein the sort technique was used by expert and non-expert therapists to describe an ideal therapeutic relation. It was also used by judges to assess therapists' performances.

Welsh and Dahlstrom (1956) describe studies by Little and Shneidman and by Barron in which the sort technique was used as a means of validating information gained from the M.M.P.I. test series.

Sheldon and Sorensen (1960) recognized the need for educators to have a means of defining and observing behavior signified by nebulous terms. They reported on the use of the sort technique to measure personal adjustment, beliefs, philosophy, and finally, they examined its use as an

instructional tool.

Morsh (1955, p. 390) developed a Q-sort for the purpose of determining student opinions of classroom instructors. He concluded that such a technique could provide a basis for comparing ratings of various instructors, determining supervisor ratings of instructors and assessing instructor improvement.

All of the foregoing studies were concerned with various kinds of psychological measurements. They do, however, serve to illustrate the vast range of possible applications that the sort technique has in the field of measurement.

A number of studies have shown the usefulness of this technique of measurement outside the field of psychology.

Schill (1961) used the sort technique to determine what mathematics concepts were used by electronics technicians in California industries. In 1965, Schill and Arnold developed curricular content in six technological areas using a similar technique.

Another variation was conducted by Andrews (1959) wherein he used the sort technique to determine public and professional opinions as to the tasks of Alberta schools.

Block (1956) reported a study in which he compared forced and unforced sorts and found that the forced method appeared to be equal or superior to the unforced method. This was followed by a study by Livson and Nichols (1956)

that attempted to assess discrimination and reliability in Q-sort personality descriptions. It was found that as more discriminations were made, reliability tended to increase.

This chapter was concerned with the development and application of Q-methodology. The concept of Q-methodology, borrowed from the psychological and social sciences, provided a quantitative method for inquiry in areas concerning behavior items signified by nebulous terms often difficult to measure or define.

CHAPTER III

INSTRUMENTATION AND METHODOLOGY

I. INTRODUCTION

The development of a set of statistical and psychological principles and techniques referred to as Q-methodology began as early as 1935, with the work of William Stephenson. Numerous applications of Stephenson's Q-methodology have been made. However, none of these included using the Q-methodology for assessing technical qualifications of electronics teachers. Therefore, it was necessary to develop a sort and a set of procedures for administering the sort to the subjects selected for participation in this study.

II. INSTRUMENTATION

An examination of the Alberta Vocational Series Senior High School Curriculum Guides for Electronics revealed that there were four major divisions to the Electronics 12/22 and Electronics 32 courses. These included content having to do with electronics systems; electronics units; electronics components and their physical principles; and finally, electronics instruments and their uses.

A study conducted by Schill and Barlow (1962, p. 27) in California revealed that there were many job classifications for technical workers in the field of electronics.

They also found that, by working within a specific job classification, a technical worker often limited himself to a single technical area. Further, there were indications that, in preparing for work in a specific job classification, a technical worker often received training in only a single technical area. Thus, it seemed possible that the individual's technical qualifications might be different for different technical areas. For this reason, it was decided that, rather than prepare a single sort for the entire course, it would be more desirable to develop and use four sorts: one sort containing concepts representative of electronic systems; a second sort containing concepts representative of electronic units; a third sort containing concepts representative of electronic components and their underlying principles; and a fourth sort containing concepts representative of electronic instruments and their uses.

The Alberta Vocational Series Senior High School Curriculum Guides for electronics and the text books listed therein provided a clear and comprehensive indication of the concepts to be covered by each part of the course. These concepts were listed on cards, one concept to a card. The complete listing of the concepts in each content area contained sixty cards. The cards were then reviewed and rewritten to ensure a minimum of duplication. As a result of this re-examination, fifty cards for each content area were retained.

The 200 cards (fifty cards for each of the four content areas) were submitted to three electronics teachers for examination. One of the teachers, G. A. Campbell, B.Sc., and Journeyman Radio and Television Technician, was Senior Instructor in the Electronics Technology Department of the Northern Alberta Institute of Technology. The second teacher, C. A. Sammons, B.Sc. and P.Eng., formerly an electronics teacher at Medicine Hat Composite High School, Alberta, was, at the time of this study, an instructor in the Electronics Technology Department of the Northern Alberta Institute of Technology. The third teacher, G. R. Rose, formerly an electronics teacher at Victoria Composite High School, Edmonton, Alberta, was, at the time of this study, a sessional lecturer in the Department of Industrial and Vocational Education, Faculty of Education, University of Alberta. Appendix A contains letters from these individuals attesting to the content validity of the cards. Appendix E shows a copy of the 200 cards that were used in this study.

Every subject selected to participate in this study was required to sort each set of fifty cards developed by the researcher into nine ordinally numbered categories. The criterion on which the cards were sorted was that of difficulty of the concepts described on the cards. Appendix D contains a copy of the Instruction Sheet issued to the subjects participating in this study.

An answer sheet was developed for recording the results of each sort to ensure a forced normal distribution of the cards as recommended by Block (1956, p. 491). Appendix F contains a copy of the Answer Sheet issued to the subjects for recording results of subjects' sorts.

Since it was necessary to have some means of associating the cards from a particular content area with its respective answer sheet, the cards and answer sheets were color coded. Each subject had only to sort the cards for each content area and then to record the results of the sort on the answer sheet of matching color. This minimized the opportunity for errors arising from the reporting of the results.

III. METHODOLOGY

Administering the Sort to the Control Group

The control group used in this study consisted of thirty-eight high school students registered in Electronics at Victoria Composite High School, Edmonton, Alberta. Arrangements for administering the sort to these students were made through the facilities of the Laboratory School Program Board, the Edmonton Public School Board, and Victoria Composite High School. Subjects were given class time to complete the sort.

Each student received four sets of cards, four answer sheets, and a detailed instruction sheet. (Appendices D, E,

and F) The students were asked to read the instructions and to complete the sort as directed. No attempt was made to associate the names of the students with their respective answer sheets, since the only information required at this time was that the answer sheets belong to the subjects in the control group. Subjects were asked to turn in their answer sheets as soon as they were finished, at which time they were asked to resume their regular studies. All students in the control group returned completed answer sheets for all sorts. Tables VII to X (Appendix G) show the tabulation of the results of these sorts.

Administering the Sort to the Experimental Group

A list of all the names and addresses of subjects for the experimental group--teachers and student teachers of electronics--was obtained from the files of the Department of Industrial and Vocational Education, Faculty of Education, University of Alberta, along with other information regarding the technical training and work experience of the subjects. The addresses were verified with those addresses recorded at the offices of the Alberta Teachers Association. Introductory letters were mailed to forty subjects (Appendix B) explaining the nature of the study. Enclosed in each introductory letter was a stamped, addressed, return post card on which the subjects were to indicate their correct mailing address and to return the post card, if they were willing to cooperate in the study. Post cards were returned

by thirty-eight subjects. Upon receipt of a post card, the researcher mailed to each of these thirty-eight subjects an envelope containing the four sorts, four answer sheets, an explanatory letter, detailed instruction sheet, and a stamped, addressed, return envelope for return of the answer sheets. (Appendices C, D, E, and F) The four sorts, the four answer sheets, and the instruction sheet were the same as those given to the students in the control group. An identifying number was typed on each answer sheet in order that subjects returning the answer sheets could be associated with their respective groups for purposes of analysis and in order that those subjects who had failed to return their answer sheets could be contacted with a follow-up letter or a phone call. Follow-up procedures were carried out which resulted in a total return of thirty-two completed answer sheets. Since this quantity represented better than eighty per cent return, it was decided to carry out the analysis of the data for the experimental group using these thirty-two sets of returns. After the analysis of the data had been completed, three additional sets of data arrived. However, these arrived too late to be included in this study. Three subjects failed to return their answer sheets, even after a follow-up telephone call, and even though they had previously indicated their willingness to cooperate in this study. Tables XI to XIV (Appendix G) show the tabulation of results of these sorts.

Data Processing

All of the data collected by means of the sort technique were punched on I.B.M. cards and were processed on the I.B.M. 7040 Computer at the Department of Computing Science, University of Alberta, using programs from the Division of Educational Research Services.

CHAPTER IV

PRESENTATION OF DATA

I. INTRODUCTION

This study was conducted to investigate whether the sort technique could be used as a means of assessing technical competence of electronics teachers. Two hypotheses were developed. The first hypothesis was concerned with the ability of the sort technique to measure between-group differences. Hypothesis II was concerned with the measurement of within-group differences of the experimental group.

In Chapter III of this study, reference was made to the sort technique and its applications to this study. Subjects were asked to complete four sorts of electronics concept cards on the basis of difficulty of the concepts.

This chapter restates the hypotheses and describes the methods used for testing the hypotheses. The critical level of significance for all calculations in this study was set a priori at 0.01.

Tables VII to X (Appendix G) show the tabulation of the results of the sorts completed by the thirty-eight high school students in the control group. Tables XI to XIV (Appendix G) show the tabulation of the results of the sorts completed by the thirty-two teachers and student teachers in the experimental group.

II. BETWEEN-GROUPS ANALYSIS

Testing of Hypothesis I

This hypothesis stated:

The sort technique used in this study will differentiate between the experimental group and the control group on the basis of their technical qualifications.

In order to get a comparison of sorts between the thirty-eight subjects in the control group and the thirty-two subjects in the experimental group, the results of each sort carried out by each subject were correlated with those of every other subject, yielding a correlation matrix for each sort. Each correlation matrix was then subjected to a factor analysis requesting two factors and a factor matrix was obtained for each sort. Subsequently, quartimax, varimax, and equimax factor rotations were carried out on the principal axes factor, and a factor matrix for each rotation was obtained for every sort.

The purpose of the above analysis was to determine whether the subjects in the experimental group (teachers and student teachers) would load on a different factor than those of the control group (high school students). Since the varimax rotations seemed to provide the greatest degree of clustering of subjects, the varimax factor matrices were retained for every sort, while all other factor matrices were disregarded. In order to compare the loadings of the two groups on the two factors, a cutting score was estab-

lished for each factor and ratios were computed to indicate the proportion of subjects in each group that fell above the cutting score. The cutting score used in this study was the mean of the factor loadings for all the subjects.

A comparison of the proportions of subjects in each group scoring above the cutting score is shown in Table I. In all cases, the ratios indicated that the subjects in the control group seemed to load most heavily on factor one, while the subjects in the experimental group seemed to load most heavily on factor two.

The significance of the difference between two independent proportions was computed for each comparison of ratios. (Ferguson 1959, p. 147) As shown in Table I, all differences except that computed for sort four and factor two were significant at the .01 level.

III. WITHIN-GROUPS ANALYSIS

Testing of Hypothesis II

This hypothesis stated:

The sort technique used in this study will differentiate between subjects within the experimental group on the basis of their technical qualifications.

The results of each sort for each subject in the experimental group were correlated with every other subject in the experimental group yielding a correlation matrix for each sort. Each correlation matrix was then subjected to a factor analysis requesting five factors, and a factor matrix

TABLE I
PROPORTION OF ROTATED FACTOR
LOADINGS ABOVE MEAN CUTTING
SCORE FOR CONTROL AND EXPERIMENTAL GROUPS

	<u>Factor 1</u>	<u>Factor 2</u>
Sort 1: Systems Concepts		
Control Group Proportion	32/38	7/38
Experimental Group Proportion	3/32	30/32
Significance of Difference (χ^2)	6.23(.01)	6.29(.01)
Sort 2: Units Concepts		
Control Group Proportion	10/38	27/38
Experimental Group Proportion	31/32	9/32
Significance of Difference (χ^2)	5.96(.01)	4.07(.01)
Sort 3: Components Concepts		
Control Group Proportion	9/38	27/38
Experimental Group Proportion	24/32	12/32
Significance of Difference (χ^2)	5.58(.01)	2.82(.01)
Sort 4: Instruments Concepts		
Control Group Proportion	14/38	19/38
Experimental Group Proportion	28/32	20/32
Significance of Difference (χ^2)	4.30(.01)	1.04(n.s.)

n.s. means that the difference is not statistically significant.

was obtained for each sort. Subsequently, quartimax, varimax, and equimax factor rotations were carried out on the principal axes factor, and a factor matrix for each rotation was obtained for each sort. Since it was found that the varimax rotations yielded the greatest degree of clustering of factor loadings, the varimax factor matrices were retained for each sort, while all other factor rotations were disregarded.

Careful examination of the technical qualifications of the experimental group revealed that there were certain common categories in the technical backgrounds of groups of subjects in this group. The most predominant categories seemed to be:

(1) the possession or lack of teaching experience by the subject;

(2) the length of time that had elapsed since the subject had completed formal training;

(3) the attainment of a satisfactory standard of technical competence through a program of apprenticeship in the radio and television repair field;

(4) the attainment of a satisfactory standard of technical competence through an electronics technology diploma program at an institute of technology; and

(5) the attainment of a satisfactory standard of technical competence through a program of training and experience in the armed forces in the field of electronics.

These categories were used to form a basis for making within-group comparisons of sorts completed by the experimental group. Cutting scores which were the means of the factor loadings for each factor were computed. For each of the above categories, the proportion of subjects in the category falling above the cutting score was computed. Similarly, the proportion of subjects outside the category falling above the cutting score was computed. (Tables II, III, IV, V, AND VI)

The group size was tested to determine whether it was large enough to use the test for significance of the difference between two independent proportions as described by Ferguson (1959, p. 147). It was found that all of the groups used for the within-groups comparisons were too small to apply this test for significance; therefore, it was necessary to utilize chi square with Yates' correction for continuity as a test for significance. (Ferguson, 1959, p. 172)

The only difference that was significant at the .01 level was that resulting from Factor Three, Sort One, when a comparison was made between those subjects who attained a satisfactory level of technical competence by completing an electronics technology program at an institute of technology and all other experimental subjects. See Table IV.

There were some instances in the experimental group where differences between groups of experimental subjects were equal to or slightly better than the .05 level of

TABLE II
 PROPORTION OF ROTATED FACTOR LOADINGS
 OF EXPERIMENTAL SUBJECTS
 ABOVE MEAN CUTTING SCORE FOR WITHIN-GROUP
 COMPARISON BASED ON TEACHING EXPERIENCE

	1	2	Factor 3	4	5
Sort 1: Systems Concepts					
Subjects with Teaching Experience	10/17	10/17	7/17	6/17	9/17
Subjects with No Teaching Experience	5/15	7/15	5/15	7/15	6/15
Significance of Difference (χ^2)	n.s.	n.s.	n.s.	n.s.	n.s.
Sort 2: Units Concepts					
Subjects with Teaching Experience	9/17	11/17	9/17	6/17	7/17
Subjects with No Teaching Experience	7/15	5/15	6/15	7/15	9/15
Significance of Difference (χ^2)	n.s.	n.s.	n.s.	n.s.	n.s.
Sort 3: Components Concepts					
Subjects with Teaching Experience	5/17	5/17	6/17	11/17	8/17
Subjects with No Teaching Experience	5/15	11/15	8/15	5/15	7/15
Significance of Difference (χ^2)	n.s.	4.52*	n.s.	n.s.	n.s.
Sort 4: Instruments Concepts					
Subjects with Teaching Experience	9/17	10/17	7/17	6/17	7/17
Subjects with No Teaching Experience	7/15	4/15	8/15	8/15	8/15
Significance of Difference (χ^2)	n.s.	n.s.	n.s.	n.s.	n.s.

n.s. means that the difference is not statistically significant.

*Signifies a significant difference at the .05 level.

TABLE III
 PROPORTION OF ROTATED FACTOR LOADINGS
 OF EXPERIMENTAL SUBJECTS
 ABOVE MEAN CUTTING SCORE FOR WITHIN-GROUP
 COMPARISON BASED ON LENGTH OF TIME SINCE FORMAL TRAINING

	Factor				
	1	2	3	4	5
Sort 1: Systems Concepts					
Subjects trained prior to 1954	6/13	7/13	5/13	6/13	7/13
Subjects trained after 1954	9/19	10/19	6/19	7/19	8/19
Significance of Difference (χ^2)	n.s.	n.s.	n.s.	n.s.	n.s.
Sort 2: Units Concepts					
Subjects trained prior to 1954	6/13	7/13	7/13	4/13	6/13
Subjects trained after 1954	9/19	9/19	8/19	9/19	10/19
Significance of Difference (χ^2)	n.s.	n.s.	n.s.	n.s.	n.s.
Sort 3: Components Concepts					
Subjects trained prior to 1954	10/13	6/13	4/13	8/13	6/13
Subjects trained after 1954	8/19	10/19	10/19	7/19	9/19
Significance of Difference (χ^2)	n.s.	n.s.	n.s.	n.s.	n.s.
Sort 4: Instruments Concepts					
Subjects trained prior to 1954	7/13	6/13	5/13	7/13	7/13
Subjects trained after 1954	9/19	8/19	10/19	7/19	9/19
Significance of Difference (χ^2)	n.s.	n.s.	n.s.	n.s.	n.s.

n.s. means that the difference is not statistically significant.

TABLE IV
 PROPORTION OF ROTATED FACTOR LOADINGS
 OF EXPERIMENTAL SUBJECTS
 ABOVE MEAN CUTTING SCORE FOR WITHIN-GROUP
 COMPARISON BASED ON RADIO-T.V. SERVICING BACKGROUND

	1	2	Factor 3	4	5
Sort 1: Systems Concepts					
Subjects with Radio-T.V.					
Training	2/9	6/9	4/9	6/9	3/9
All Other Subjects	13/23	11/23	8/23	8/23	12/23
Significance of Difference (χ^2)	n.s.	n.s.	n.s.	n.s.	n.s.
Sort 2: Units Concepts					
Subjects with Radio-T.V.					
Training	6/9	5/9	2/9	2/9	3/9
All Other Subjects	9/23	11/23	13/23	11/23	13/23
Significance of Difference (χ^2)	n.s.	n.s.	n.s.	n.s.	n.s.
Sort 3: Components Concepts					
Subjects with Radio-T.V.					
Training	5/9	5/9	4/9	4/9	3/9
All Other Subjects	14/23	11/23	10/23	11/23	12/23
Significance of Difference (χ^2)	n.s.	n.s.	n.s.	n.s.	n.s.
Sort 4: Instruments Concepts					
Subjects with Radio-T.V.					
Training	7/9	4/9	5/9	3/9	6/9
All Other Subjects	9/23	10/23	10/23	11/23	11/23
Significance of Difference (χ^2)	n.s.	n.s.	n.s.	n.s.	n.s.

n.s. means that the difference is not statistically significant.

TABLE V
PROPORTION OF ROTATED FACTOR LOADINGS
OF EXPERIMENTAL SUBJECTS
ABOVE MEAN CUTTING SCORE FOR WITHIN-GROUP
COMPARISON BASED ON TECHNOLOGY DIPLOMA BACKGROUND

	1	2	Factor 3	4	5
Sort 1: Systems Concepts					
Subjects with Electronics					
Technology Diploma	1/8	6/8	7/8	1/8	4/8
All Other Subjects	14/24	11/24	5/24	12/24	11/24
Significance of					
Difference (χ^2)	n.s.	n.s.	8.71**	n.s.	n.s.
Sort 2: Units Concepts					
Subjects with Electronics					
Technology Diploma	4/8	3/8	6/8	2/8	6/8
All Other Subjects	11/24	13/24	9/24	11/24	10/24
Significance of					
Difference (χ^2)	n.s.	n.s.	n.s.	n.s.	n.s.
Sort 3: Components Concepts					
Subjects with Electronics					
Technology Diploma	4/8	4/8	4/8	5/8	1/8
All Other Subjects	14/24	12/24	10/24	10/24	13/24
Significance of					
Difference (χ^2)	n.s.	n.s.	n.s.	n.s.	n.s.
Sort 4: Instruments Concepts					
Subjects with Electronics					
Technology Diploma	7/8	5/8	4/8	2/8	6/8
All Other Subjects	9/24	9/24	11/24	11/24	10/24
Significance of					
Difference (χ^2)	4.17*	n.s.	n.s.	n.s.	n.s.

n.s. means that the difference is not statistically significant.

*Signifies a significant difference at the .05 level.

**Signifies a significant difference at the .01 level.

TABLE VI
 PROPORTION OF ROTATED FACTOR LOADINGS
 OF EXPERIMENTAL SUBJECTS
 ABOVE MEAN CUTTING SCORE FOR WITHIN-GROUP
 COMPARISON BASED ON ARMED SERVICES TECHNICAL TRAINING

	Factor				
	1	2	3	4	5
Sort 1: Systems Concepts					
Subjects with Armed Services Training	6/8	2/8	1/8	4/8	3/8
All Other Subjects	9/24	15/24	10/24	9/24	12/24
Significance of Difference (χ^2)	n.s.	n.s.	n.s.	n.s.	n.s.
Sort 2: Units Concepts					
Subjects with Armed Services Training	3/8	4/8	3/8	6/8	4/8
All Other Subjects	12/24	12/24	12/24	7/24	12/24
Significance of Difference (χ^2)	n.s.	n.s.	n.s.	n.s.	n.s.
Sort 3: Components Concepts					
Subjects with Armed Services Training	5/8	6/8	4/8	3/8	5/8
All Other Subjects	13/24	10/24	10/24	12/24	10/24
Significance of Difference (χ^2)	n.s.	n.s.	n.s.	n.s.	n.s.
Sort 4: Instruments Concepts					
Subjects with Armed Services Training	1/8	3/8	4/8	6/8	2/8
All Other Subjects	15/24	11/24	11/24	8/24	14/24
Significance of Difference (χ^2)	4.17*	n.s.	n.s.	n.s.	n.s.

n.s. means that the difference is not statistically significant.

*Signifies a significant difference at the .05 level.

significance. Ferguson (1959, p. 66) considers these differences as not significant, but approaching significance. First in this category was the difference resulting from Factor Two, Sort Three, where a comparison was made between those subjects who had taught in a school system and those who had never taught. See Table II. A second difference approaching significance arose from Factor One, Sort Four, where a comparison was made between subjects who were graduates of an electronics technology program and all other subjects. See Table V. The final difference approaching significance arose from Factor One, Sort Four, where a comparison was made between subjects who attained technical competence in the armed forces and all other subjects. All other differences were not significant.

It was felt that the within-group comparisons were seriously inhibited by the relatively small sample size that resulted when the experimental group was subdivided into comparison groups.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

I. SUMMARY OF THE STUDY

This study was conducted to investigate the applicability of the sort technique as a means of assessing technical qualifications of electronics teachers. Knowledge of this kind is required by vocational teacher education institutions as an aid to a better understanding of vocational teacher characteristics which, in turn, could contribute to the improvement of professional courses in curricula.

Thirty-two electronics teachers and student teachers and thirty-eight high school students studying electronics were asked to sort four sets of cards containing electronics concepts representative of concepts specified in the Alberta Vocational Series Senior High School Curriculum Guides for electronics on the basis of perceived difficulty of the concepts. All sorts for all subjects were correlated with each other and the correlations were subjected to a factor analysis. The factor loadings for the two groups were analyzed using a cutting score. The analysis showed that the subjects in the control group (high school students) loaded more heavily on one factor, while the subjects in the experimental group (electronics teachers and student teach-

ers) loaded more heavily on a different factor.

Subsequent to the above findings, the sort results of the experimental group were correlated with each other. These correlations were then subjected to factor analysis and the resulting factor loadings were analyzed, using cutting scores, to determine the extent to which the sort results would yield an identification of factors relating to technical qualifications of subjects in the experimental group. Five selected factors were examined. Of these, only one factor showed a statistically significant difference in relation to a single sort. Three other factors showed differences that approached significance in relation to three other sorts. All other differences were not statistically significant. While it is possible that no actual difference in technical qualifications existed in these cases, it is pointed out that the small sample sizes made a proper test for significance difficult.

II. CONCLUSIONS

The following general conclusion is derived from this study:

The sort technique can be used effectively to separate subjects into groups on the basis of their technical qualifications.

The following conclusions are specific for this study:

1. The results of the sort used in this study showed a difference in technical qualifications between the experimental and the control groups.
2. The results of the sort used in this study showed some isolated differences between subjects within the experimental group on the basis of their technical qualifications.

III. DISCUSSION AND IMPLICATIONS

The sort technique, such as the one used in this study, seems to have the potential for use as a method of evaluating technical qualifications. In this study, no attempt was made to quantify the relative extent to which subjects possessed technical qualifications.

It appears that a sort technique could be used to help vocational teachers, directors and teacher educators in the selection of prospective candidates for teacher education programs. This becomes increasingly significant at the University of Alberta with the inception of the Vocational Education "Route Two" program in the Department of Industrial and Vocational Education. (Faculty of Education Calendar, 1967-68, p. 64) A sort technique would prove beneficial in the initial selection of candidates for this program. Further utilization of the sort technique could be made to measure changes in the technical qualifications of a candidate as he progresses through the various stages of the "Route Two" program.

Finally, the sort technique could serve as an evaluative instrument in the Industrial Arts Multiple Activity Laboratory. Sorts by subjects could be used to indicate attainment of levels of proficiency and understanding of abstract concepts. This, along with sorts designed for likes and dislikes of activities in the various areas could provide valuable information for use in plotting student profiles with respect to interest and ability. As indicated above, the sort technique could serve as an indicator of changes in student performance brought about as a result of the laboratory exposure.

IV. SUGGESTIONS FOR FURTHER RESEARCH

This study seemed to indicate differences in technical qualifications between the experimental and the control groups. However, many of the differences within the experimental group were not statistically significant. It is possible that replication of this study, using larger groups would reveal additional information with respect to the within-group differences.

In order to assess technical qualifications of individuals, it would be desirable to have a standardized sort that would characterize individuals who have attained a satisfactory standard of technical competence in electronics. Additional research could be directed toward developing such a standardized sort, along with techniques for assessing

sorts in relation to this standardized sort.

Perhaps, with the rapid changes that are taking place in the world of work today, it is inevitable that technically qualified individuals will find it necessary to upgrade their qualifications to keep up with these changes. The development of techniques for analyzing the results of sorts could yield valuable information to individuals with regard to their need for upgrading.

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APPENDIX A

**NORTHERN ALBERTA INSTITUTE OF TECHNOLOGY**

1762 - 106 STREET, EDMONTON

PHONES: 474-7366
479-6501

June 19, 1967

Mr. M. W. Petruk
Department of Vocational Education
University of Alberta
Edmonton, Alberta

Dear Milton:

In reference to your letter requesting an analysis of the cards in your sorting program.

The concepts on the cards are typical of the concepts presented in the present grade 10, 11 and 12 curriculum in the Vocational High Schools.

At the present time, these concepts are covered in our Year A and Year B programs in the electronics technology, (here at the Institute). Most of the concepts are taught in the Year A program, with the rest spread out over the Year B program.

Yours sincerely,

G. A. Campbell
Senior Instructor
Electronics Department

GAC:bd



NORTHERN ALBERTA INSTITUTE OF TECHNOLOGY⁴⁹

11762 - 106 STREET, EDMONTON

PHONES: 474-7366
479-6501

March 14, 1967

Mr. M. W. Petruk
Faculty of Education
University of Alberta
Edmonton, Alberta

Dear Sir:

I have inspected the set of 200 cards that you prepared, and find that they are representative of the Electronics 12, 22 and 32 courses that are offered in the Province of Alberta.

I taught these courses over a period of three years (1963-1966) at Medicine Hat Composite High School, Medicine Hat, Alberta.

Yours truly,

C. A. Sammons
Instructor
Electronics Department

CAS:bd



April 3, 1967

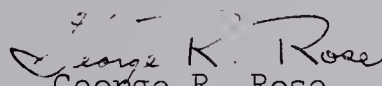
Mr. M. W. Petruk
Dept. of Industrial and
Vocational Education
University of Alberta
EDMONTON, Alberta

Dear Milton:

In compliance with your recent request, I have completed the examination of the 200 concept cards you plan to use in your research study.

On the basis of my involvement in the preparation and teaching of Electronics 12/22 and Electronics 32 since their inception in 1963, it is my personal and professional opinion that the concepts identified on the 200 cards are an accurate and adequate representation of the content of these two courses.

Yours truly,


George R. Rose
SESSIONAL LECTURER

GRR/vy

APPENDIX B



Dear Colleague:

I have recently undertaken the task of writing a thesis in which I propose to investigate the extent to which a modified Q-sort can be used to determine areas in which technical upgrading should be offered to vocational teachers. In order that I may evaluate this instrument, I am asking for your cooperation in sorting a number of cards in a specified manner. However, to insure that you receive the cards, I am enclosing a stamped, addressed post card on which I would like you to write your correct address. As soon as I receive your card, I will forward details regarding your contribution to this study.

I would be happy to send you a copy of the results of this study as soon as they are available.

Thank you for your cooperation. I am certain that I will be able to return the favour when you begin to work on your thesis.

Yours truly,

M.W. Petruk.
Department of Industrial and
Vocational Education

MWP/se
encl.



APPENDIX C



Dear Colleague:

The number of people in the Province of Alberta who specialize in the teaching of electronics is relatively small and we are often separated by so many miles that it is difficult to meet to discuss experiences and compare ideas. Your participation in a study designed to find an effective sorting test is very much appreciated and is one way for you to express your opinions about the material in the electronics curriculum.

Your judgement about the relative difficulty of the electronics material printed on the enclosed cards is important, but it would be of the greatest value if you would express your opinions by completing the special sheets which are enclosed according to the step-by-step procedure shown on the instruction page.

You do not need to put your name on the answer sheets when you return them since this study is not intended to be used to make any individual evaluation of those of you who are participating.

When you have completed sorting the cards and filling in the answer sheets, you are welcome to keep the cards for your own use and the use of your students.

Please try to complete the answer sheets according to the directions and return them to me at your very earliest convenience.

Let us hope that this cooperative effort will succeed in gaining new ideas for curriculum improvement and suggest additional areas for better teacher education.

Appreciatively,

M. W. Petruk

APPENDIX D



INSTRUCTION SHEET

1. Enclosed are 200 cards, 50 of which are yellow, 50 are orange, 50 are pink and 50 are blue.
2. All of the cards have statements about technical content in the Electronics 22 and 32 curricula, one concept on each card.
3. Yellow cards are concerned with components.
Orange cards are concerned with units.
Pink cards are concerned with systems.
Blue cards are concerned with instruments.
4. Before you start to sort, READ all of the YELLOW cards. As you read the cards, do not waste time trying to solve the problems presented. Simply concentrate on the concepts presented.
5. Sort the YELLOW cards into three piles
EASY MEDIUM HARD
EASY means that you think the concepts on these cards are relatively easy to understand. This pile shall consist of 12 cards.
MEDIUM means that you think the concepts on these cards are not easy and yet not difficult to understand. This pile shall consist of 26 cards.
HARD means that you think the concepts on these cards are relatively difficult to understand. This pile shall consist of 12 cards.
6. Now sort the easy pile of yellow cards into 3 piles
#1 #2 #3
Place the 2 easiest cards in pile #1.
Place the 4 medium cards in pile #2.
Place the 6 hardest cards in pile #3.
7. On the lower right-hand corner of each card is a number. Write these numbers in the corresponding squares in columns 1, 2, and 3 on the YELLOW answer sheet.
8. Now sort the medium pile of yellow cards into 3 piles
#4 #5 #6
Place the 8 easiest cards in pile #4.
Place the 10 medium cards in pile #5.
Place the 8 hardest cards in pile #6.
9. Record the numbers on the lower right corners of these cards in the corresponding squares in columns 4, 5, and 6 on the YELLOW answer sheet.



INSTRUCTION SHEET CONTINUED

10. Now sort the hard pile of yellow cards into three piles.

#7 #8 #9

Place the 6 easiest cards in pile #7.

Place the 4 medium cards in pile #8.

Place the 2 hardest cards in pile #9.

11. Record the numbers on the lower right corners of these cards in the corresponding squares in columns 7, 8 and 9 on the YELLOW answer sheet.

12. Repeat steps 4-11 using the orange cards and answer sheet.

13. Repeat steps 4-11 using the pink cards and answer sheet.

14. Repeat steps 4-11 using the blue cards and answer sheet.

15. Mail the answer sheets.

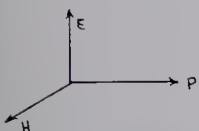
Thank You.

APPENDIX E

The following are reduced-size photographic copies of the 200 sort cards that were administered to the subjects participating in this study. Pages 60 to 62 show cards covering concepts related to electronics systems; pages 63 to 65 show cards covering concepts related to electronics units; pages 66 to 68 show cards covering concepts related to electronics components and their underlying physical principles; and pages 69 to 71 show cards covering concepts related to electronics instruments.

For best transfer of energy from the transmitter to the antenna, the transmission line ensures that energy is not expended at any point, it decreases gradually to the end of the line where it may be dissipated.

200



A magnetic field produces an electric field in space. This in turn creates a magnetic field. The fields are related to each other as shown and have a direction of propagation, P.

205

To insure that the antenna is tuned to the current frequency, the antenna may be loaded with a series inductance or with a shunt capacitance.

201



The above represents the equivalent circuit of an antenna.

203

The total field around an antenna may be represented as the vector sum of an electric field, an induction field and a radiation field.

204

Parasitic oscillations are oscillations that occur at frequencies other than the desired frequency. They may cause interference and they consume power. They may be minimized by changing the lead dress and by inserting suppressing resistors.

210

Single sideband suppressed carrier transmission is most efficient but requires reinsertion of the carrier before the signal is demodulated.

211

Parallel resonance π represents a condition of maximum plate impedance. This may be detected by observing the smallest plate current.

212

Class C power amplifiers may be used in high level modulating circuits. For low level modulation, a class B power amplifier is used.

214

A frequency multiplier is an amplifier biased to class C to produce distortion and thereby harmonics. Then the tuned plate circuit need only be tuned to a harmonic rather than to a fundamental.

215

Buffer amplifiers add gain to RF signal and serve to isolate the output from the oscillator, whence modulation or keying at the output will not load or detune the oscillator.

220

High level modulation means that the last stage of a transmitter is being modulated, whence a large amount of audio is needed to modulate with. However, the amplifier stages need not be linear.

221

Modulation may be accomplished by varying the grid voltage of the RF power amplifier with the audio voltage. It takes far less audio voltage to modulate 100% using this system as compared to plate modulation.

223

Plate modulation consists of coupling the audio into the plate circuit so that on negative 1/2 cycles, the audio cancels E_{bb} reducing the RF amplitude to zero, while on positive 1/2 cycles it raises the RF, making its amplitude larger.

224

Single sideband transmission results when the RF at the antenna contains only one sideband frequency and the carrier frequency.

225

The modulation envelope is a duplicate of the audio frequency and is the resultant of adding 3 RF sine waves. The modulation envelope itself is not transmitted.

230

A typical filter capacitor should have a resistance of about 100,000 ohms while a leaky one has about 10,000 ohms.

234

The extent to which an antenna radiates energy is related to the physical length of the antenna and is inversely proportional to its length.

232

The received audio output is proportional to the percentage of modulation at the transmitter, but if modulation exceeds 100%, distortion occurs.

The BFO in a communications receiver is placed at the detector to insert a frequency 1 KC. less than the IF. Hence when CW is received, the beat difference frequency is audible at the speaker.

241

A ratio detector differs from a Foster-Seely in that the output of a Foster-Seely is a sum of voltages while in a ratio detector, the output is a ratio as developed in a bridge circuit. This means the ratio detector needs no limiter.

242



A Foster-Seely discriminator develops an audio signal proportional to the rate of frequency change based on the principle that frequency change causes phase shift which causes voltage change.

243

231

Bandspread may be accomplished mechanically by gearing down the rate of rotation of the tuning capacitor or electrically by placing a small variable capacitor in parallel with the tuning capacitor to bring about a small shift in frequency.

240

A limiter removes amplitude variations from a frequency modulated signal. This is accomplished by an amplifier which has been biased class A₂ and is saturating. Hence the input to the limiter must be relatively large.

245

Good AVC action depends on maximum emitter-base bias control which is also controlled by the bias stabilization circuit. Hence bias variability produced by AVC is stabilized. Hence one must compromise between bias stability and AVC.

253

One would expect to find a Bias voltage of about -10 volts on the oscillator grid of a converter if it is oscillating.

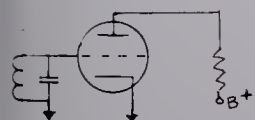
262

When two frequencies are mixed in a non-linear amplifier, the output includes the two original frequencies, their sum, and their difference.

271

A squelch circuit eliminates noise in the speaker when no signal is being received by raising the bias of the audio output to cutoff.

282



The plate detector above is biased close to cutoff whence the tube operates class B, acting as a Detector.

290

An AM-FM combination receiver uses the IF amplifier and the audio amplifier sections for both AM and FM purposes. There are however two separate converters and two separate detectors. The IF amplifier operates at two different frequencies.

250

Neutralization in a transistor radio consists of a small amount of negative feedback introduced by circuit constants. This prevents oscillation at high frequencies.

254

Adjusting the RF section, one must couple the RF signal of the correct frequency into the RF tuner by radiation. Otherwise, the tuned RF circuit will not produce a voltage peak at resonance.

263

The functions of both the local oscillator and the mixer may be combined into a single tube; the pentagrid converter.

272

While plate decoupling lowers the DC voltage applied to the plate, it is necessary in order to overcome feedback effects that arise as a result of having a common power supply for all stages.

283

The sensitivity of any receiver is defined as the amount of RF signal voltage needed at the antenna to provide 1 volt of output at the detector.

291

The phono switch in a radio-phonograph combination removes the demodulated output from the volume control and inserts the output from a phono pickup in its place. Hence one may conclude that a combination that works on phono but not on radio has a fault in the circuits preceding the detector.

251

The mixer-oscillator in a transistor radio consists of an oscillator in the emitter-collector circuit and an RF input at the base.

255

Adjusting the converter consists of varying the frequency of the oscillator so that it is higher than the frequency of the RF section by the amount of the IF frequency.

264

An RF preselector may be used to improve selectivity of a superheterodyne receiver.

274

The major advantage of a superheterodyne receiver is the fact that it has fixed tuned amplifiers thus offering a fixed gain to all signals, regardless of the frequency at which they are received.

284

The TRF receiver consists of an RF amplifier to amplify the desired frequency, a detector, and an AF amplifier to amplify the audio signal.

292

A typical transistor radio would normally draw 4 to 10 milliamps of current.

252

The filament circuit in an AC/DC radio usually consists of all the filaments connected in series. Filaments of different voltage ratings may be used provided the total is equal to the line voltage. The current rating of all the tubes must be the same.

260

The mixer-oscillator stage in the superheterodyne is designed so that the output of this stage is always a fixed frequency regardless of the frequency to which the receiver is tuned.

270

Low intermediate frequencies have increased stability, gain and selectivity, but more spurious responses may result.

280

A TRF receiver is aligned at the high end of the dial by injecting a modulated RF signal of the correct frequency and adjusting the RF stages for maximum output. Circuits nearest the detector are aligned first.

285

Additional sensitivity may be attained in a TRF receiver by adding more RF stages and coupling the shafts of the variable capacitors together for ease of tuning.

293

A trimmer capacitor used in aligning RF stages has the greatest effect at the high frequency end of the range.

Sensitivity of a receiver is controlled by using an RF stage consisting of a variable μ tube with variable cathode bias resistance. Increased sensitivity is attained by reducing bias so that the tube functions on the steepest part of the curve.

295

294

controls in an amplifier circuit simply serve to change the frequency response of an amplifier so that it accents either high or low frequencies.

100

If the switch in the above circuit is closed, the electrostatic field stored in the capacitor will collapse, creating a magnetic field around the coil. This in turn will collapse, inducing a current which will charge the capacitor.

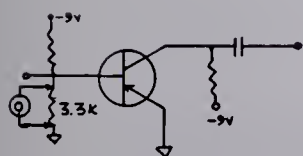
113

Oscillation in an oscillator circuit actually takes place outside the tube or transistor. The only function the tube or transistor serves is to provide energy to the remaining circuitry at the correct time in order to sustain oscillation.

121

A one watt increase in power output of a 2 watt amplifier will be more readily noticed by the ear than a one watt increase of a 20 watt amplifier. To compensate for this, loudness of sounds is measured as the logarithm of the ratio of powers.

125



An ohmmeter connected across the 3.3K ohm resistor as shown might read 3.3K ohms or zero, depending on the polarity of the ohmmeter.

133

A cathode follower amplifier operates with a high degree of negative feedback whence it has a net gain of less than one.

141

The overall gain of a cascade is equal to the product of the individual stage gains.

102

A colpitts oscillator uses a capacitive voltage divider as a feedback network.

114

One way of defining an oscillator is by referring to it as an amplifier with positive feedback. This means that a part of the amplified output voltage is used as an input signal which the amplifier amplifies to attain the output voltage.

122



Amplitude distortion results with excessive signal input. It causes clipping of the output wave, which has the same effect on output as introducing odd harmonics.

130

The input impedance of a common base amplifier is about 200 ohms while the output impedance is much higher; about 200,000 ohms.

134

Forward bias in a transistor amplifier accelerates the electrons so that they could reach the collector. In addition, it insures that none of the distortion associated with zero bias will be present.

142

A snub damping resistor placed across the load of a single-tuned R. F. amplifier serves to broaden the bandwidth of that amplifier.

110

Oscillators that depend on grid leak bias to operate may be checked for operation by measuring the grid bias with a voltmeter. Absence of bias means that the oscillator is not working.

115

In a capacitively tuned amplifier, the bandwidth remains constant while Q varies directly with resonant frequency. In an inductively tuned amplifier, the bandwidth varies directly as frequency squared and Q varies inversely as resonant frequency.

123

Phase splitting, necessary in push-pull operation, may be accomplished by using two stages of amplification. The first will provide 180° of phase shift while the second will return the phase angle to zero.

131

The common emitter amplifier provides 180° of phase shift at the output compared to the input.

135

Full B+ voltage at the plate of an amplifier means that the tube is not conducting whence $I_b = 0$ and the IR drop across the load resistor is zero.

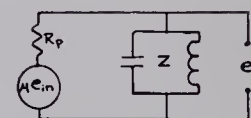
143

When two stages of amplification are coupled by means of a double-tuned transformer, the selectivity of the stage depends on how closely the transformer windings are coupled.

111

The armstrong oscillator achieves positive feedback by transformer coupling AC changes in the plate circuit to the coil in the grid tank circuit.

120

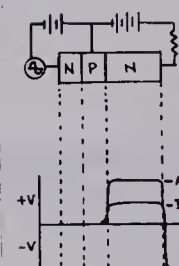


The voltage equivalent diagram of an rf amplifier readily shows that e_o and hence gain depends on the size of Z, in fact,

$$A = \frac{\mu Z}{r_p + Z}$$

To enable an output stage which has an impedance of about 10,000 ohms to effectively drive a speaker whose voice coil is 4 ohms, a transformer whose ratio is 50:1 should be used.

132



The effect of the positive 1/2 cycle of signal is to aid forward bias, and therefore to reduce the size of the potential hill from level A to level B.

140

To plot a Load Line, one must determine the end points:

$$X = E_{bb}/R_L \text{ and } Y = E_{bb}$$

X is the point where $E_b = 0$

Y is the point where $I_b = 0$

To amplify D. C. signals, one need only eliminate the inter-stage coupling capacitor. The grid of the second tube will be positive with respect to ground but negative with respect to its own cathode.

145

An amplifier may be made to favor higher frequencies by making the load inductive. Similarly, it may be made to favor specific ranges of frequencies by making the load a parallel tank.

153

Gain, A may be found from tube parameters by

$$A = \mu R_L / (R_L + r_p)$$

161

The primary function of an amplifier is to take in small signals and to put out larger signals.

165

A full wave rectifier makes use of phase inversion. This results in a DC average output which is twice as large as that of a half wave.

173

An amplifier with cathode biasing may be made to have some additional gain by adding a bypass capacitor across R_k such that $X_C = R_k/10$.

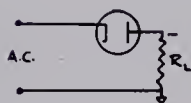
150

A Hartley oscillator uses feedback from the collector circuit. The transistor may be viewed as a negative resistance which overcomes the damping effect of the tank.

154

A single stage common cathode amplifier has a 180° phase shift between input and output because output voltage is $E_{bb} - I_b R_L$. As input voltage rises, I_b rises, hence output voltage drops.

162



A negative power supply voltage may be attained by simply reversing the direction in which the diode is connected.

170

The effect of filtering on a rectified voltage is produced because the filter capacitor stores energy while the rectified voltage is at its peak and releases energy while the rectified voltage is at zero.

174

The extent to which a power supply maintains rated voltage under varying load conditions is found by $\frac{E_{n1} - E_{f1}}{E_{f1}}$

182

An amplifier may be biased by placing a resistor in the cathode circuit where the size of the bias is determined by $I_b R_k$. This has the added advantage of limiting I_b in the event that it should begin to rise suddenly.

151

Since it is the purpose of an amplifier to amplify signals, one of the most important characteristics of an amplifier is a graph showing amplifier gain for various frequencies.

155

In an amplifier, the grid is biased negatively but the amount of negative voltage is varied by the input signal. As the signal swings positively, the grid becomes less negative and the plate current rises.

163

A power supply has two essential purposes, namely to provide proper sizes of voltages and to provide rectification of AC as required by a given piece of equipment.



A bridge rectifier produces a full wave rectified output as shown by the arrows in the diagram.

171

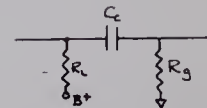
175

Electrolytic filter capacitors are used in power supplies because of their large capacity and small physical size.

183

The efficiency and the distortion of an amplifier may be varied by varying the amount of bias and the size of the input signal an amplifier receives. Whence class A_1 has least distortion but is least efficient, while class C_2 is efficient but highly distorted.

152

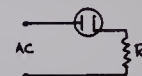


An RC coupling circuit consists of a coupling capacitor between the output or plate load of one stage and the input or grid of the following stage. The capacitor simply blocks DC but provides a relatively easy path for AC signal.

160

The essential parts of an amplifier circuit are a tube, a plate load, a B supply, a grid load and grid bias voltage.

164

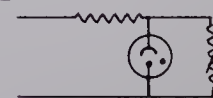


It is the load, R , across which the rectified voltage is developed. However this only happens when positive half cycles are applied. On negative half cycles, the diode acts as an open circuit.

172

The voltage doubler can provide high DC voltage as long as small currents are drawn. However if the current is large, the load resistance is small and the RC time constant becomes small, whence the capacitors discharge more rapidly than they are charged and the output voltage drops.

180



A gas tube will provide voltage regulation because reduced load current tends to raise output voltage which causes increased current through the regulator.

184

The effectiveness of a power supply filter system is expressed as ripple voltage divided by DC voltage.

181

A parallel tuned circuit has a low impedance to frequencies other than the resonant frequency hence an oscillator using a parallel tuned circuit will produce only the fundamental sine wave to which it is tuned.

190

A doubling of power is approximately a 3db. gain while a doubling of voltage is approximately a 6 db. gain.

191

The distribution of electrons in the orbital rings of the Bohr model of an atom determines its electrical stability and therefore determines the relative conductivity of the element.

1

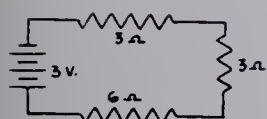
Potential as used with reference to voltage between two points is derived from the fact that stored electrons have a certain potential energy which becomes kinetic energy as soon as electrons begin to move from one point to another.

2

Current in a circuit is the rate at which electrons move through the circuit - a quantity inversely proportional to the opposition offered by the circuit but directly proportional to the potential applied to the circuit.

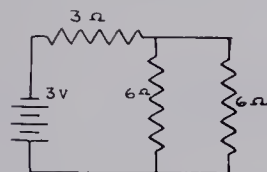
3

A quantity of electricity, whether they be passing through a circuit at a given rate or whether they be stored in a dielectric, is measured in coulombs



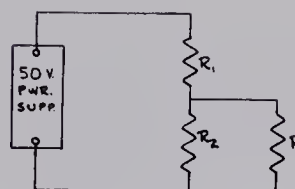
The size of voltage that exists across each resistor may be computed by $E=IR$ because I is the same in all parts of the circuit.

5



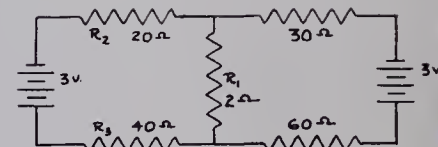
The voltage applied across each of the 6 ohm resistors is 1.5 volts.

6



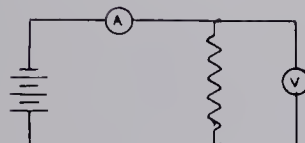
If R requires 10 volts and 1 amp., then the voltage ratio $R_1:R_2$ must be $\frac{1+R_1}{R_1+R_2}$

11



The current in R_1 is $1/3$ amp. down, while the sum of the voltages across R_1 , R_2 , and R_3 is 3 volts.

12

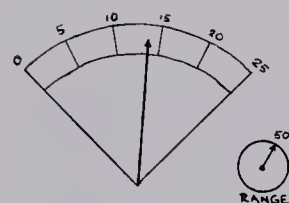


The value of a resistor that has color bands red, green, yellow, gold is 260,000 ohms and its tolerance is 5%.

13

To measure current, the circuit must be broken and an ammeter A inserted in the circuit while to measure voltage, one need only connect voltmeter V .

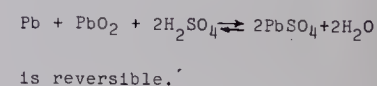
15



The above meter reading is 280.

16

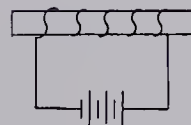
The reason that a secondary cell such as the lead-acid cell can be recharged is that its chemical reaction



21

The internal resistance of a source [using the voltage equivalent diagram] whose no-load voltage is 100 volts and whose full-load voltage [at 1 amp] is 50 volts is 20 ohms.

23

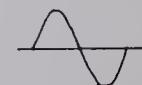


In the above picture, one can determine the polarity of the magnet using the left hand rule.

24

Permeability is a ratio expressing the proportionate extent to which a material in a core of an electromagnet concentrates the flux, as compared to an air core.

25



To completely describe the above waveform, one must know its shape, amplitude, period and phase angle in relation to some arbitrarily chosen reference.

32

One microweber or 100 lines of flux represents the entire group of lines present between the poles of a moderately strong magnet.

30

The average number of flux lines contained in a unit of area is the flux density B , measured in Gauss.

31

Back emf in a coil carrying alternating current will contribute to the opposition of the current. Such opposition is called inductive reactance, X_L .

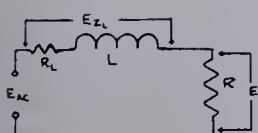
34

The area enclosed within a graph of B vs. H of an electromagnet is proportional to the energy expended due to hysteresis within the core.

40

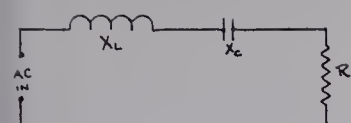
While an A.C. sine voltage reaches a peak value of 10 volts during its cycle, the amount of heating effect it produces in a resistor is equivalent to 7.07 volts.

41



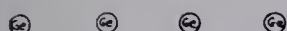
One may find X_L by measuring E_{K_L} and hence computing the current in the circuit. Then X_L is the vectorial difference between E_{K_L} and IR_L divided by I .

33



Theoretically, L and C consume no power, while R consumes all the power that the source supplies. This is because L and C store the energy that is fed into them and return it to the circuit at a later time.

42

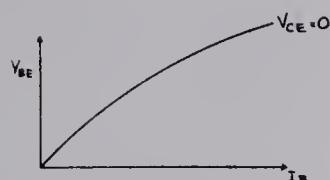


N-type semi-conductor has excess electrons because the valence of the donor is 5.

50

Three phase power results from an alternator which has three windings and the output of each winding is 120° out of phase with the output from the other two windings.

43



The above represents a graph from which one may derive h_{ie} .

51

Semi-conductor materials are made by doping elements that normally have four valence electrons with other elements that have three or five valence electrons.

54

To completely describe the operation of a triode, one needs to plot a plate characteristic, a transfer characteristic, and a constant current characteristic, however, given one of these characteristics, one may derive the other two.

62

In looking at transistor operation, it is often best to think of current being carried in the semi-conductor by holes, which move in a direction opposite to that of electrons.

55

Since electrons flow from cathode to plate of a diode, one can think of a conducting diode as a resistor. However, since the value of such resistance varies with current, it must be described by means of a graph.

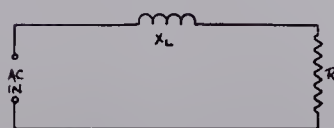
63

Tetrode characteristics are obtained in a manner much the same as triode characteristics except that the screen is held at the manufacturer's recommended voltage.

70

G_m is a value which expresses the degree of control a grid has over plate current, hence the larger this factor is, the smaller a change in grid voltage is needed to initiate a large change in plate current.

71



The total opposition offered by the circuit on the left is shown vectorially on the right. This may be expressed:

$$Z = R + jX_L - jX_C$$

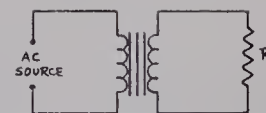
75

Resonance occurs if X_L and X_C in a circuit containing these elements in series or parallel are equal.

74

A transformer consists of two inductors arranged so that current changes in the first will induce a voltage in the second.

44



Looking at the amount of current and voltage supplied by the source, one can determine that the source sees R to be $[N_p/N_s]^2$ times as large as it really is.

45

The alpha of a transistor describes the ratio of collector current to emitter current in a transistor circuit.

52

Electrons flow through a PN junction when it is forward biased because the barrier voltage across the junction has been reduced to zero.

53

While the majority carriers in a semi-conductor material might be holes, a small amount of electron flow will also be present. These electrons are referred to as minority carriers.

60

Since like charges repel, the best way to make sure that the grid of a tube does not attract any electrons from the plate current is to make the grid always remain negatively biased.

61

Whenever any substance is heated, the surface tension that holds electrons and/or atoms together is overcome because of the energy that heat imparts, hence they break away. This is why a hot cathode emits electrons.

64

Amplification factor of a tube expresses the absolute ceiling beyond which the gain of an amplifier may never go.

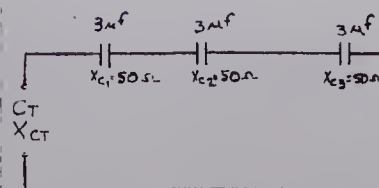
65

Q of a resonant circuit expresses the magnification factor of that circuit, hence in a series circuit, the voltage across the capacitor will be Q times the applied voltage.

72

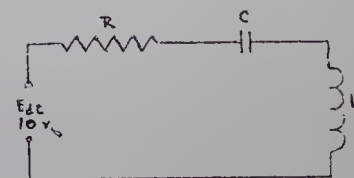
In a series resonant circuit, the impedance of the circuit is minimum at resonance while in a parallel resonant circuit it is maximum.

73



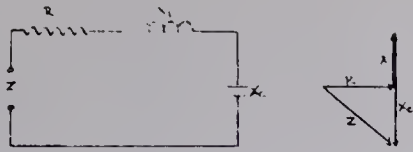
$$C_T = 1 \text{ microfarad but } X_{CT} = 150 \text{ ohms}$$

80



If the above circuit is resonant then it is possible to have 100 volts across the inductor even though the source is 10 volt

81



The total opposition offered by the above circuit must be found by adding R and X_L and X_C vectorially at 90° to each other. However, X consumes no power.

82

The minimum value of the back-to-front resistance ratio of a non-vacuum diode is 1000 ohms.

90

The D'Arsonval or Weston meter movement operates on the motor principle, where a moving coil of wire rotates within a constant magnetic field due to a current flowing in the wire.

300

If a meter is intended to measure current, its resistance must be as low as possible so that when it is placed in series with the circuit, the current will remain approximately the same as it was without the meter.

301

To extend an ammeter range from 0 - 1 amp to 0 - 2 amps, add a resistor in parallel with the meter such that the resistance of the meter equals the resistance of the parallel resistor.

302

One may convert an ammeter to a voltmeter simply by inserting a large series resistor.

303

The Ayrton shunt is a fixed value for all current ranges. However, various sizes of currents are fed in through taps in the shunt.

304

Sensitivity of a voltmeter is the inverse of its current rating and is measured in units "ohms per volt".

305

Voltmeters should have a very high resistance, since the lower the resistance, the more current is passed through the meter, thereby reducing the voltage being measured.

310

Resistance may be measured using a milliammeter in series with a battery. The higher the resistance being measured, the less the meter will read.

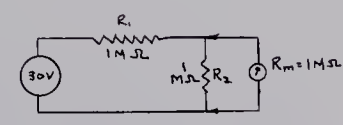
311

A shunt ohmmeter has a scale that reads from left to right and is linear. The meter in such a circuit is always connected across the source.

312

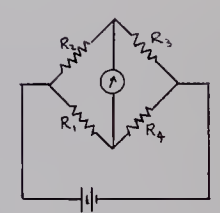
A wattmeter is basically a Weston movement in which the permanent magnet has been replaced by an electromagnet. This electromagnet is placed in series with a circuit while the moving coil is placed in parallel. Thus the needle reads power.

313



The actual voltage across R_2 is 15 volts without the meter but is reduced to 10 volts when the meter is added to the circuit.

314



When the meter reads zero,
 $R_1 R_4 = R_2 R_3$

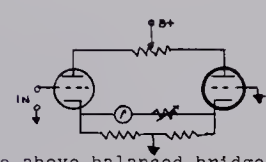
315

A basic rule to follow whenever using test instruments is to set the range selector switch to the highest range and then to decrease this setting till the needle is as far up the scale as it will go without going off the top end of the scale.

320

Accuracy of a meter is the greatest percent of error one could expect at full scale deflection. Hence a .2% meter on the 100 volt range reading 100 volts means that the actual voltage present is between 98 and 102 volts.

321



In the above balanced bridge VTVM, R_1 may be adjusted so that the current in both tubes is the same when the input is grounded, Whence M will read zero.

322

A typical VTVM has a 50 megohm voltage divider circuit incorporated into its range selector so that the meter input impedance is 50 megohms regardless of the range that the selector is at.

323

The probe on a VTVM simply provides diode rectification of the signal. The meter then reads the amount of rectified DC that is present.

324

The ohms adjust setting of a VTVM is carried out with an open circuit (infinite resistance) between the probes. This will give full scale deflection since at this point, maximum negative bias is applied to the balanced triode bridge.

325

Focusing a cathode ray oscilloscope consists of varying the positive potential of Accelerating anode #1 while the potential of anode #2 is constant.

330

The size of a voltage may be determined on a CRO by applying the voltage to the vertical input of the scope and comparing the amount of deflection thus obtained to the amount of deflection obtained from a known voltage source.

331

One complete cycle of a voltage waveform may be displayed on a CRO screen if that voltage is applied to the vertical input while a sawtooth voltage is applied to the horizontal deflection plates. The frequency of the two waveforms must be the same.

332

Aquadag serves as a return path for secondary electrons emitted from the phosphorus screen.

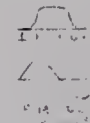
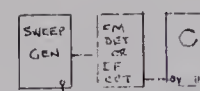
333

A low capacitance probe is basically a direct probe equipped with series decoupling resistors to isolate the circuit under test from the capacity of the lead and the instrument circuits. This can prevent the instrument from detuning RF circuits under test.

334

An audio generator often consists of two stages of amplification with feedback through a Wein bridge which will determine the frequency at which regeneration will occur.

335



The Above test rig is useful for obtaining frequency response curves as shown.

A lamp is used in the cathode of a Wein bridge oscillator to stabilize the amplitude of oscillation.

340

G_m , as read by many tube checkers, is a measure of how effective the grid is in changing plate current. Hence if a tube has a G_m of 1500 and it is rated at 3000, a change of 1 millivolt at the grid is half as effective in changing plate current as it should be.

341

An oscilloscope may be connected to a transmitter by loose coupling the vertical input to the transmitter output and by connecting the modulating transformer to the horizontal output. A modulation pattern for 100% modulation would appear:



342

An RF generator may be calibrated by zero-beating its signal with a known signal such as a crystal oscillator or a radio station.

344

A sweep generator may be used as a source of an FM signal, but a marker must be added to identify specific frequencies produced by the sweep generator.

345

A figure 8 Lissajous pattern on an oscilloscope connected to identify the hum frequency in a circuit indicates that the hum frequency is 120 cycles.

350

In measuring the phase difference between two signals at the horizontal and vertical plates of a scope, an oblique line sloping at 45° from left to right indicates a phase difference of 180° .

352

A common means of testing the size of reactive components is to compare their effect in a bridge circuit with the effect of known standard reactive componen

353

A signal tracer is simply a TRF receiver. It may be used to amplify RF signals, IF signals or audio signals in order to isolate a stage that is inoperative.

354

The sweep output terminals of a sweep generator simply provide a variable frequency output for convenience, much like the audio output terminals in an R.F. generator.

360

The grid dip oscillator can be used to determine the resonant frequency of any parallel tuned circuit regardless of whether the circuit is connected for operation or not.

361

A grid dip meter is a variable frequency Hartley oscillator with a microammeter in the grid circuit. If the tank circuit is brought near an external tank of the same frequency, energy is absorbed and there is a reduction in grid leak bias whence the needle dips.

362

The time base in a triggered oscilloscope provides a measure of the period rather than the frequency of a waveform.

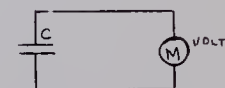
364

The use of an ohmmeter across the emitter and collector of a transistor will identify a short in that part of a transistor.

365

Using an ohmmeter to check the emitter-base junction of a transistor may bias the transistor forward and thereby damage it.

371



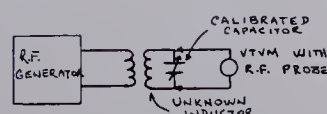
The above circuit may be used to determine the size of C by noting the length of time it takes for C to discharge [ie. for the meter reading to reach zero].

380

A Q-meter may be used to find L or C if the test frequency is known since $X_C = X_L = RQ$.

Then $L = X_L / 2\pi f$ or

$$C = 1 / 2\pi f X_C$$



1. Measure C at resonance [Emax]
2. Measure C_1 below resonance [.707 Emax]
3. Measure C_2 above resonance [.707 Emax]

Then, $Q = 2C / C_1 - C_2$.

382

A nuvistor is a miniature vacuum tube less than 1/5 the volume of the largest conventional vacuum tube in which the elements are suspended cantilevers, making the tube more rugged, reliable and efficient.

390

A thermistor is a semiconductor with a very high negative temperature coefficient of resistance, thus it is useful for detection, measurement and control of heat energy

391

381

Peltier effect is the component of heat evolved or absorbed at junctions between two dissimilar elements when current flows through the circuit.

392

Seebeck potential is the voltage produced in a circuit of two dissimilar elements when one junction is heated relative to the other.

393

APPENDIX F

YOUR I.D. NUMBER

[illegible]

Place the identification numbers of the concepts you identified as EASIEST or least difficult at this end

Place the identification numbers of the concepts you identified as HARDEST or most difficult at this end

APPENDIX G

SORT RESULTS OF MEMBERS OF THE CONTROL

GROUP SORTING THE SYSTEMS CARDS

IDENT. NO. OF CARD	IDENTIFICATION NUMBER OF PERSON DOING SORT
	1-----THROUGH-----38
1	44683875637457885689233442636445323572
2	72254424433645444356654538734756542953
3	74332122313337556565275323742421354482
4	32357253456458447553352836645135344345
5	52123111213221413112112221122121232311
6	33351222545425225422433221213424328251
11	83743646859848378778269459585897762256
12	83443432655236358944347476797869875485
13	24111331242221932112511132321212211236
15	23513213131112212422426312211214121152
16	53422763225413921541491224643547454213
21	63866279754459746984345765478646545996
22	54542565485652546556423334583654269825
23	52575776869358879554575544737735755345
24	14253333145424121221422145435432434435
25	64587687446586865637756373565556677547
26	55657796548666656878355477754386656666
30	95899687448985673468599575555977658688
31	41968667666554146544543785533676666764
32	54434664797796334544855547856868843436
33	69665444854597786796765856886868885455
34	45746546354735435453557646344565386357
40	55899948978688768635887798876768778548
41	36578555763454648647874645294653754334
42	27356345664333565335867666776574559745
43	56978997662966599576988665549787696499
44	46445565255434622463645336122353423322
45	76666677548876587897574757845887856777
50	17374333541563264775163544548552146574
51	68756876776779775879987699676999987868
52	77544344552567453455746883564554677577
53	77476465537553665847634964457346562874
54	28354338533553363775543684444453548544
55	42255433433563565365444574367566497843
60	46534445324665454665454466667645466676
61	32465454525552642243436315433333214453
62	65648865974775657658786967969477775568
63	55445556674686536456675767454385433564
64	81534826525535334335252635623345447524
65	65736759776344553656736558656745335567
70	65427578587774767536575785358663643566
71	85687556482765457365668663366644536667
72	57537555486367575357655853775555553636
73	66754644365645474643346554454483565585
74	46222554356244234234654452452235465724
75	38776787897874396787668557987552777453
80	55665462354142644223524243275224645135
81	78565545676347557764368555655564554753
82	39685654665645753586737446568636664755
90	96865788767876885464566478365478585649

SORT RESULTS OF MEMBERS OF THE CONTROL

GROUP SORTING THE UNITS CARDS

IDENT. NO. OF CARD	IDENTIFICATION NUMBER OF PERSON DOING SORT 1-----THROUGH-----38
100	47637164444541653144352544322254244437
102	15545541474365642433512725176216974816
110	84865267786554559865576546567564586365
111	65647755744566475656768566833548754676
113	46572555356647464552543332621446535722
114	68888976868976574744886767378873482257
115	56878656568794477795443757384333338337
120	78758888988875546548699858687994554359
121	87749788847866697647656897456565752547
122	95757856679866578649645936575545622258
123	69448452714579346547625688874682868596
124	88146575628678245657744759583781769375
125	16666538416752552866445614796767443464
130	63795524495454925374237623834445547754
131	36365476688554654556464435555465347558
132	56345662236525144555354457654234535478
133	53232372161769483312768516354535524924
134	77563643463545125257553544454564455565
135	34354485454255664438664663433637654854
140	57856747697788968659899276769785363499
141	54435785837655456465676545787675786467
142	74376365566788267378745676577578443684
143	85544132344443545535242484463361475566
144	25257413675478287556985952763769493775
145	68422894663664376784435598955655748564
150	54255323347245412256577562543523265388
151	25357555522355345475728586657557675636
152	44475269634585856885653655666856667865
153	45636757576667256545557553736844256546
154	67769896949966879878826879698699864257
155	63654644554245825484364665446353426422
160	73764344553447336464576231745432845633
161	92223673655656725226736672562688699573
162	64536657435697755466448483655852554475
163	46421225523534732675355465535544545663
164	55444431132135444423231328242253257921
165	31113213241211611111132421121117113511
170	52534346255433568551464155245123613142
171	72663425352113731233131245225342121532
172	43883476355424534772453244315524356143
173	52453535356432684723565367455476756254
174	35655546442536857644554346432326535645
175	24585337557332586367875375219957666344
180	23574663585443465562366465645658362455
181	35357565775322663334224334564446337853
182	37896757775787897995387773967777975786
183	51421444223323534323414144344336437643
184	76574959765653733783657844456475871745
190	46512534536354753636575433548454576635
191	49686668867877868967987757878766688785

SORT RESULTS OF MEMBERS OF THE CONTROL

GROUP SORTING THE COMPONENTS CARDS

IDENT. NO. OF CARD	IDENTIFICATION NUMBER OF PERSON DOING SORT 1-----THROUGH-----38
300	95774766333644559788584684847656737577
301	47424324624451646442332631323411543143
302	34646345444543675443266632136724575255
303	44524143244432132413216754124221465265
304	63655466635879563677859358866885875395
305	23224522245412415212643953422233466434
310	43233232431223355132222611534253323322
311	51134213322226125333236425433422636544
312	2235423432616436512453452737345455542
313	66453885636645657565465675837347868746
314	45333421346145234781121382273532127635
315	35212637532536562264433365539735792958
320	12333341112314515752341142211114311111
321	43455133353354333555554543212532548555
322	77445546544555266684465679555487664426
323	25432322521246452265423646774725566355
324	34345543234632421427645734434334456634
325	14115214214422727528523434421175646531
330	56462755555753546764642763365587565623
331	96989559575453644447384773955645774975
332	35874765965767755847453286765655244663
333	63978557777958938879899348462957484684
334	51566855446554755955645544355338342535
335	75556754477274373655455325696466513545
340	44565568889536474537767766557648372737
341	46465632556454454774364944644552736444
342	87556575464541786696454372756796457976
343	77755456774767489544746559785796659457
344	63857464675745864336355565645667252656
345	6557766556634477545567555657854553466
350	65889997499976598979315485758949978588
351	54894687793867594623586556687353685824
352	37565684555583866546767473887665654563
353	52555354565666663546545235275543345376
354	74686487873665537465545655546656234454
355	65566565988487675737888516758857762478
360	56677658465477453765673565356347436558
361	58758696667566878884677826459544254766
362	55788766867677788576678857597468655669
363	49733756456655952336566445652553121247
364	76667477767386264364877257648479753666
365	56341545153335251243554164465463427354
371	32221434346535346353436234443784548443
380	24443373442355623561746457574574465362
381	67646646655598634576762867544375687859
382	76547473658798587495757548586974999775
390	88676979883663857355157493665365576783
391	58342545658735446656534776343276337212
392	88698858788889547658998867966866885897
393	89767878757878346858978498664666844887

SORT RESULTS OF MEMBERS OF THE CONTROL

GROUP SORTING THE INSTRUMENTS CARDS

IDENT. NO. OF CARD	IDENTIFICATION NUMBER OF PERSON DOING SORT 1-----THROUGH-----38
200	35253258235753457343686867624678752446
201	53234672545656535248645514464385652465
203	54311111114164115411867475132291367354
204	54656776599587376527748576788786977657
205	76667824442478246389959354746856888586
210	36685587866357698256533555594575545243
211	49464436455622555748756333757852752848
212	76527713625356624635465554265753145456
214	36232362723455244125464456656578825873
215	66434463653578584557547756674533353779
220	64554536676864456766647835356647753758
221	64663645234364674736153734874538446788
223	28485573453352976365375622666559564665
224	43775424546475943366688427686664746464
225	19464644544626754541755336347867533537
230	36795666566856888654834458568735546566
231	54756559768645866432574577468654665634
232	72355535462256365544636456763465658876
234	45623245357235441425844787422564626653
235	12133232325276212124145425232225555732
240	45866755355532763577365682755454483785
241	45786658778732768678587982895984562675
242	85577598767969886566898969879678869799
243	95546797758969686968999989995696599596
245	54476855958517657557355777886633634375
250	54356445847747665465523775569653645334
251	54346456441711547473372171555416254144
252	61122121134134121412516583164646325135
253	57779968556887765987477548947486636747
254	48244443442588475886637626657852785675
255	48465585476687555746666828677757793588
260	63631644544464523374322131533211515322
262	82547274335498234453414564222145567415
263	68532664674565644664766638577465548464
264	85565364876365573654353765443556387565
270	75777856967531763673453692535334563524
271	75373534667433335482241262331144476313
272	57445557285576458552231615215233431422
274	91947777874723537634776263455547454544
280	27524332559775544848585645356769577552
282	36655367351556332263434365411375381442
283	67352363664245753745665546385573843956
284	37859345693643457995454254445425415352
285	66998987537655899366553556534362637254
290	73815553613484332755478645675795279867
291	42454629546645352555245447536534444636
292	27888776285443566533222443523326276241
293	53668886485844477854525345443426366631
294	2354844528354444835554354344247134223
295	85543455732323626267766263743447434965

SORT RESULTS OF MEMBERS OF THE EXPERIMENTAL

GROUP SORTING THE SYSTEMS CARDS

IDENT. NO. OF CARD	IDENTIFICATION NUMBER OF PERSON DOING SORT 1-----THROUGH-----32
1	66829664954987442657645574553445
2	65253483755352543768344234344434
3	44572342553262333544153522253621
4	43234433572431413264553125312323
5	41312352324223333243242433221522
6	41394343415223424234254423442533
11	8456687667752579689546466666758
12	93488775638425867796565385588544
13	23121121111113113111171212141211
15	32413223324233332313231323122614
16	22421151248114124572215131725269
21	98358636539385534568985534614556
22	32355954765554774454465553534466
23	24655826836455766666676755556758
24	54442242224333441142322314342122
25	54345656514554433756335448454655
26	17473365663656985667555373956956
30	65155647282734476534565886355566
31	24234414554634372755532452735366
32	85954725586384562777636444665356
33	77787667898669788886878569869747
34	36667555642376554355653735737573
40	76975698574677954669536687978887
41	76535464763544225563428535866443
42	59553686337578545636448657586977
43	36826354565746856457927542894552
44	32421325412244324444213254122443
45	44486876747766868879796567587866
50	58745633255846885222379957575755
51	85799448996877798987766998697689
52	53576548466755677733867655544254
53	78845756475566657324459357457774
54	45743743353656666341356667466474
55	54846774566494665466737468753267
60	65758555474483577556568865546785
61	35532254335452234444484244233332
62	75767486786577659876775676477687
63	76445536445654554575554756449545
64	53234562425441335442343861454145
65	46548534545745745745554747475678
70	6546555343645545425583456455353
71	57576565656545648655745358535654
72	66666597664756856648896876767876
73	67657439857567456458554345435835
74	35654377546567267435324746234634
75	89686989679879589985665798675698
80	52364657487568265533656678773355
81	67667767747668656546477765665645
82	48677878868898677787847549686678
90	57565445152945555653684686463497

SORT RESULTS OF MEMBERS OF THE EXPERIMENTAL

GROUP SORTING THE UNITS CARDS

IDENT. NO. OF CARD	IDENTIFICATION NUMBER OF PERSON DOING SORT
	1-----THROUGH-----32
100	71245423334443355538371233655314
102	43145436152645712422354264541233
110	34544645465577465557635677688755
111	71355785666575646875754563665677
113	54523556424353166658334334443564
114	14537445467545575422716335635746
115	53565534244435253222623345424456
120	34666444346566335535845456468546
121	53566645953594566365444542753458
122	55464354854594453355452735334626
123	84887898589589788799899778978988
124	87976967577658797978767869875997
125	75754763555866867176667594964638
130	95444577595364843564567758757665
131	67544546445555665563487655565487
132	34474432665643647836496456453644
133	66495658735335665643374456787565
134	84556378277445636452348285747876
135	56255456553355656543565463544336
140	68695967555969799755769989579685
141	46728584546676837566557355346577
142	85965776764776578755547887558555
143	23666523633444253444643644353322
144	89689657687657676776886846696674
145	65836575667363865686674785485766
150	48889885456566754544636458476477
151	53565566572363555356556657236354
152	75577688866785575737565557637773
153	66656566679477538668766763576755
154	57655675578687579897855578669885
155	54657226653465346373454554453462
160	33544452332232422235524747435544
161	68788759698848987786686976876899
162	38777847875653464357565665554543
163	45427354824146324635433442335545
164	22342124342232421441241224222221
165	12111112121121111111112111121111
170	46332434343711253224273523344334
171	43231211221222442543222321222133
172	46422343433434543554222532314232
173	56312565745354544684445445655463
174	37363232414224243445555365434433
175	97443651956964444665375345565264
180	55853797576776657467938667867455
181	22333364754433344454545424242425
182	69778669387857784966786876796759
183	22234335212712332213133112112342
184	45453875735628578647453666767567
190	66555553468756555475657573554656
191	77778766588888986889978694886858

SORT RESULTS OF MEMBERS OF THE EXPERIMENTAL
GROUP SORTING THE COMPONENTS CARDS

IDENT. NO. OF CARD	IDENTIFICATION NUMBER OF PERSON DOING SORT 1-----THROUGH-----32
300	35553253547546441333455512323344
301	54243331325422343155443413242314
302	31444822538445544235444443462716
303	22444642118312342135444124212122
304	76486568756844447885665883285656
305	24543163754545653657314345345645
310	44253342446133523435352133442342
311	52662244416341312233451534551322
312	55451455352555752655655585444647
313	64624485657569575657455454464754
314	44315843835225562495345245243553
315	14524353664856285775223245746536
320	22133121331151211313114421411251
321	35122342334254133442625432173232
325	55961454683676466567573476655673
330	65535456565553245759967564465296
331	53432636454333245544131536333323
332	97555737747593856357666946525645
333	25334275232943126446744628325453
334	41596574745544768658377558876876
335	66887675869886767876585886658678
340	65345595666966437636585795637588
341	65663537577467754565633455687854
342	78742473588777975869876556767878
343	48777958868477788678769687684656
344	36826737555232634442447654626427
345	66963648687656584654868765658465
350	77616764476665823358537974975456
351	53667736262457775541632256336174
352	99795763585686974776958677887877
353	85464247677346665634685425445411
354	43567517324222635441342595547564
355	65678687475667897784828857777756
360	53546575464324327652366642535555
361	54765646356554554566777659856765
362	77779766767498574577797769556967
363	33375414445464533422624661376333
364	88435665574768556685836554776257
365	53432525223735335214245274553534
371	56954554143576455544253367435435
380	66564355824638376526534363184644
381	76668659695658588986789387899555
382	88859999995759689998796858999989
390	46356247441645465223652766455488
391	36556566646485464764563375534436
392	67287588652785657775556775664767
393	77258488673875656464584633564785

SORT RESULTS OF MEMBERS OF THE EXPERIMENTAL

GROUP SORTING THE INSTRUMENTS CARDS

IDENT. NO. OF CARD	IDENTIFICATION NUMBER OF PERSON DOING SORT 1-----THROUGH-----32
200	66475587685884676668375554466638
201	36664767656565686848386232673655
203	11411473672346267547713134427573
204	87955787885778967999779474867857
205	85947883998878888989899797998967
210	76535852553564777556667455354655
211	58724774567486788886388776776687
212	45566332543547344565544566253553
214	67574476465547475554568565555766
215	75825744645498746456666886785745
220	85637567677552544645644646477475
221	55666568757943653435681773643345
223	58436466566756355565455553656648
224	69786846775757445767756957565969
225	67665447374445674675368454576263
230	46577655764587876777386686765636
231	26345595789684865687437673736545
232	36543534643565654676555365624323
234	76354896478777668758455351673796
235	13132414351715135211154242342262
240	73374135549725427443531565868575
241	55623525464236547353635626556445
242	98658969895799699887967868887877
243	99899969988779899898998978999769
245	48779467657346547576776866534677
250	62788448365432676733422669665535
251	22212253152623125121232151141133
252	31555314437122215123223444724212
253	65868778877767788776867897889866
254	47577768766874445665877657657454
255	57295586265954555756646657453585
260	32161241333311232443142315341212
262	25455655352454231232825335114396
263	63737653526565566544474746476848
264	55556655534355333654526428553554
270	44553553545252553445533325515334
271	54687374858275933474273535545438
272	22264173146133711325643217242141
274	34332324223323553332533234245424
280	74458555446666542465754442768686
282	44444236442446556554416782465424
283	55756652526644766454565765588742
284	74443434436461653364545423352563
285	64556646434555454334454548545454
290	47543636755458464547667385455556
291	53226241323533432562445554424456
292	43362325234233324212344543232371
293	53343325214334454233554543334484
294	34444552511865322325255434336354
295	86885645654656365656752679637727

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